ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 5, Special Issue 3, March 2016*

National Conference on Recent Advances in Electrical & Electronics Engineering (NCREEE'16)

Organized by

Dept. of EEE, Mar Baselios Institute of Technology & Science (MBITS), Kothamangalam, Kerala-686693, India

On 17th & 18th March 2016

Comparison of a Neutral Leg with single Rectifier Having Two independent Voltage Outputs

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ABSTRACT:- Half-bridge rectifiers are able to provide two voltage outputs and offers three voltage levels, but the two voltage outputs depend on each other and also on system parameters. Moreover, the two voltage outputs contain large ripples because the currents following through the split capacitors contain significant fundamental frequency components. Conventional half-bridge rectifier cannot work with only one of the dual loads connected. An independently controlled neutral leg is added to conventional half - bridge rectifiers to address these drawbacks. Neutral Leg Single Phase Rectifier consists of a rectification leg and a neutral leg. The neutral leg is used to control the two voltages independently, with reduced ripples at the fundamental frequency. Neutral Leg with input filter further reduces the voltage ripples, makes the input current sinusoidal and improved Output Voltage with reduced ripples. MATLAB 2014a version software is used to simulate the model.

KEYWORDS:-Neutral Leg, Single phase Rectifier, Single Phase Rectifier with input filter, Half Bridge Rectifier, Independent Voltages

I. INTRODUCTION

Due to the penetration of renewable energy systems, more microgrids are connected to the public power grid via power converters. In both DC and AC microgrids, AC is always rectified to DC when supplying DC loadsIn many situations, it is quite normal to have single-phase utilities so single-phase rectifiers are very popular. Half-bridge rectifiers [3] are able to provide two voltage outputs, but they are depend on each other, on system parameters and they contain large ripples because the currents are following through the split capacitors contain significant fundamental frequencycomponents. After analysing the drawbacks of halfbridge rectifiers [1], an independently controlled neutral leg is added toaddress the drawbacks of the conventional half bridge rectifiers. The rectification leg from half-bridge rectifier is controlled to maintain the DC voltage. As a result, the two voltage outputs are regulated independently.

II .NEUTRAL LEG SINGLE PHASE RECTIFIER

The Neutral Leg Single PhaseRectifier composed of a rectification leg and a neutral leg. The rectification leg inherits the functions from conventional half-bridge rectifiers. The neutral leg is formed by two switches $Q_3$and Q_4,an inductor and two split capacitors. The current i_c is the key to solve all the problems, if i_c is free from providing the fundamental ripple current, the fundamental voltage ripples can be eliminated completely and if i_c can be regulated, then the two voltages can be independently controlled.

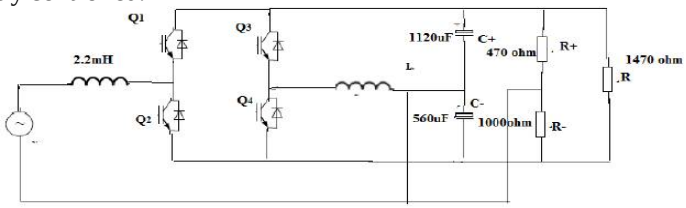

Figure 1 Neutral Leg Single Phase Rectifier

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The output voltage ripples can bereduced because the fundamental current component that originally flows roughthe split capacitors can be diverted and flows through the neutral leg. As a result,the required capacitors become smaller in order to achieve the same level of voltageripples

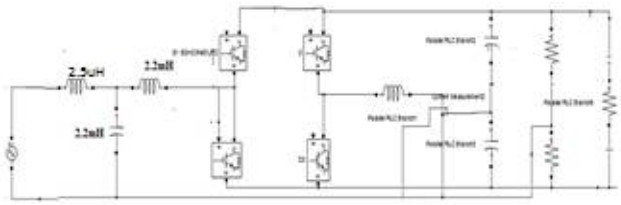

Figure 2 Neutral Leg Single Phase Rectifier with input filter

It is well known that no DC current can flow through capacitors and thus, the DCcomponents must be equal to 0, which means thefollowing condition$\left(\frac{V_+}{R_+} = \frac{V_-}{R_-}\right)$. If only a single load R is connected, then $R_+ = R_-$=infinite. The condition can be satisfied because$\frac{V_+}{R_+} = \frac{V_-}{R_-}$. In this case, the rectifier can be operatedfor any load R. The Neutral Leg Single Phase System with input filter [2] further reduces the voltage ripples, makes the input current sinusoidal and voltage ripples are reduced.

III. DESIGN PARAMETERS

3.1 The voltage across 1120u F and 560 uF is designed from the following equations 1 and 2.

$$V_+ = \frac{V_{DC}\frac{R_1}{R_2}}{1+\frac{R_1}{R_2}} \text{.....(1)}$$

$$.V_- = \frac{V_{DC}}{1+\frac{R_1}{R_2}} \text{.....(2)}$$

.

3.2 Switching Cycle for Q_1 and Q_2

$$D = \frac{V_+}{V_{DC}} - \frac{V_s}{V_{DC}} \sin \omega t \quad \text{.....(3)}$$

The switching frequency is taken as f_s = 25 kHz. D_{min} and D_{max} is obtained as 0.4and 0.6. We have chosen duty cycle as 0.48.

3.3 Switching Cycle for Q_3

$$D_{min} = \frac{1}{V_{DC}}(V_+ - V_-) \text{.....(4)}$$

$$D_{max} = \frac{1}{V_{DC}}(V_+ + V_-) \text{.....(5)}$$

For a source voltage of 110V we obtain D_{min} and D_{max} as 0.35 and 0.5. We havechosen duty cycle as 0.4. The Switching frequency is taken as 25kHz.

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Table 1. Design Parameters

Parameters	Values
Supply Voltage	110V
Line Frequency	50Hz
L_s	2.2mH
C_+	1120uF
C_-	560uF
R	1470 ohm
R_+	470 ohm
R_-	1000 ohm

Filter is designed so that inductor and capacitor are designed as 2.5µH and 2.2 mF.

IV. SIMULINK MODEL AND RESULTS

The comparison of a Conventional Single Phase Rectifier, Neutral Leg Single PhaseRectifier and the Proposed Neutral Leg Single Phase Rectifier is done with the help ofMATLAB SIMULINK model.

Conventional System

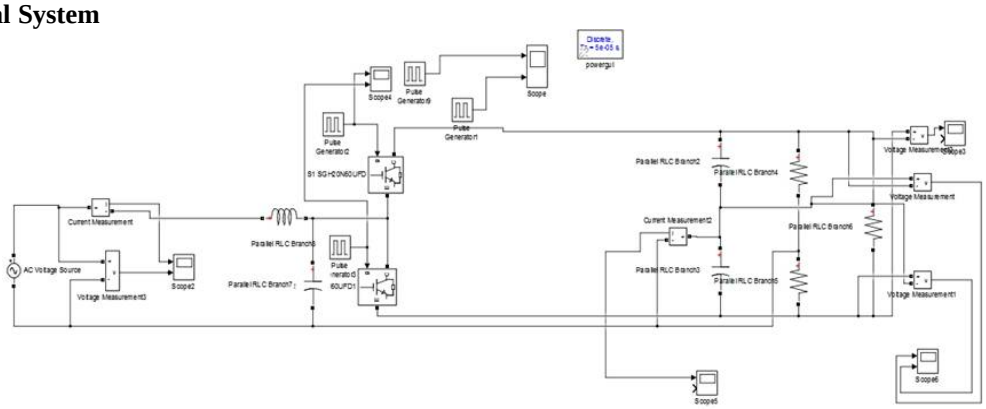

Figure 3. Simulink Model of Conventional system

The Switching frequency is taken as 25kHz and the duty ratio as 0.48.The voltage across the R load is observed varying 160V and 165V. The voltage across the $R_+$is observed varying 67V and 73V and the voltage across the R_- is varying89V and 96V.

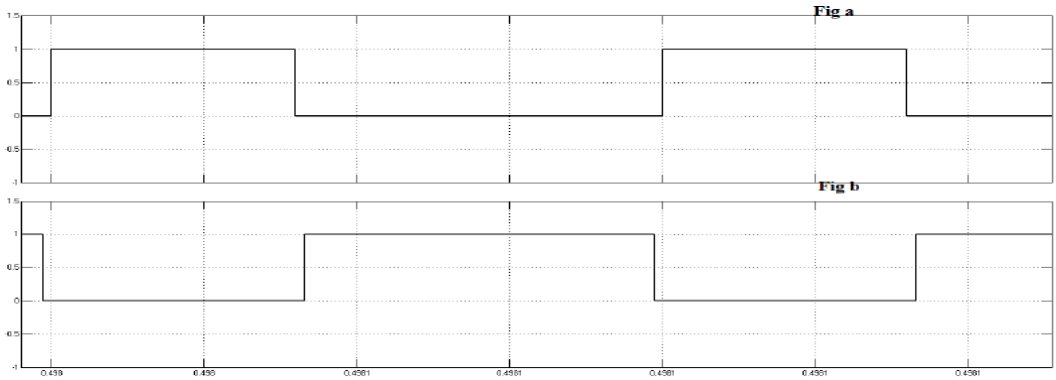

Figure 4. Gate Pulses of Q_1 and Q_2

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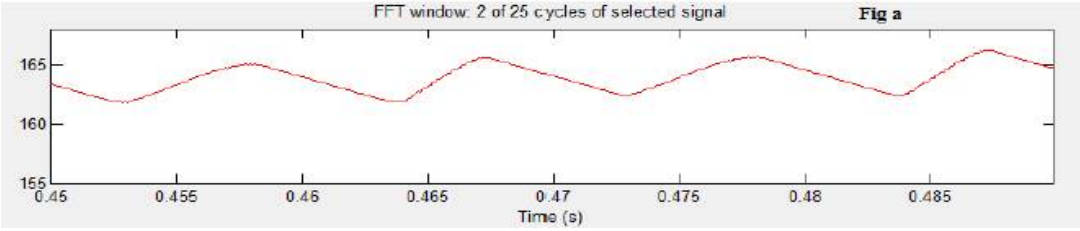

Figure 5. V_{DC} of Conventional system

Neutral Leg Single Phase System

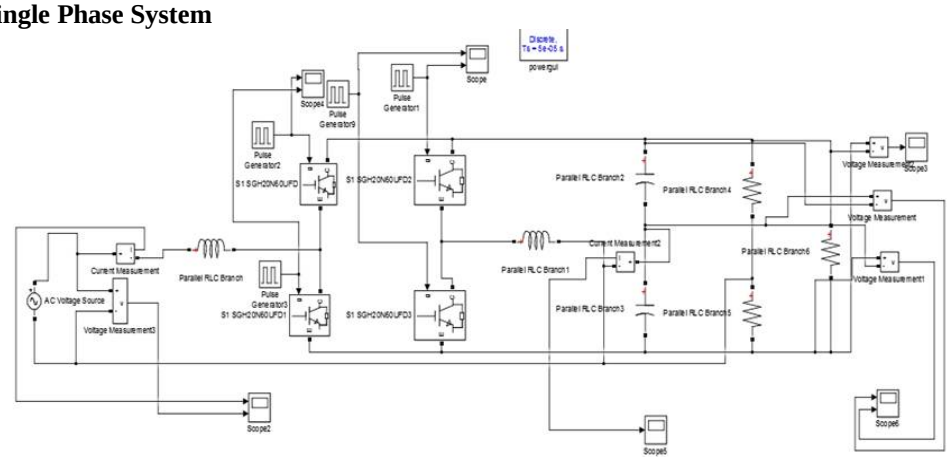

Figure 6. Simulink Model of Neutral Leg Single Phase Half Bridge Rectifier

For a source voltage of 110V we choose Duty cycle as 0.4 and the switching frequency is taken as 25kHz.The voltage across the R load is observedvarying 161V and 165V and the voltage across the $R_+$is observed varying 66V and 70V. The voltage across the R_- is observed varying 91V and 95V and the voltage rippleis observed as 4V.

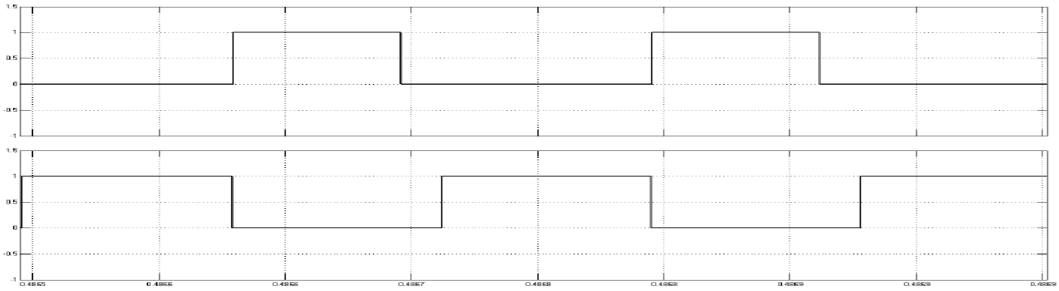

Figure 7. Gate Pulses of Q_3 and Q_4

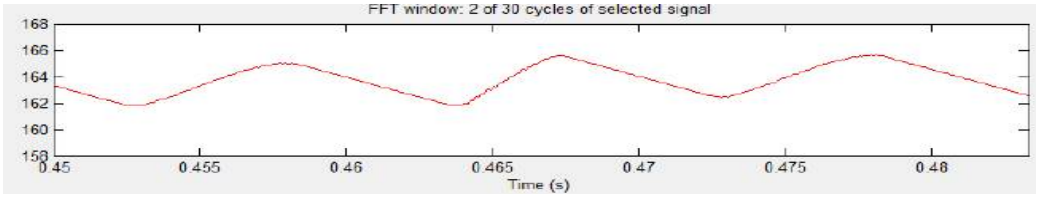

Figure 8. V_{DC} of Neutral Leg Single Phase Rectifier

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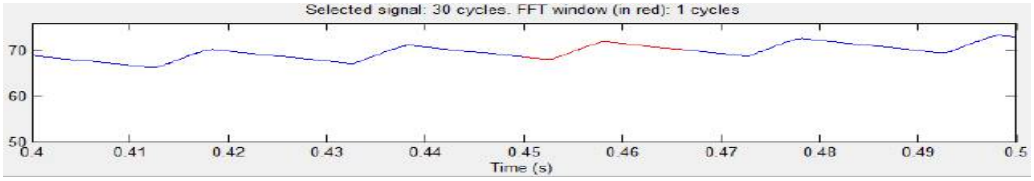

Figure 9. V_+ of Neutral Leg Single Phase Rectifier

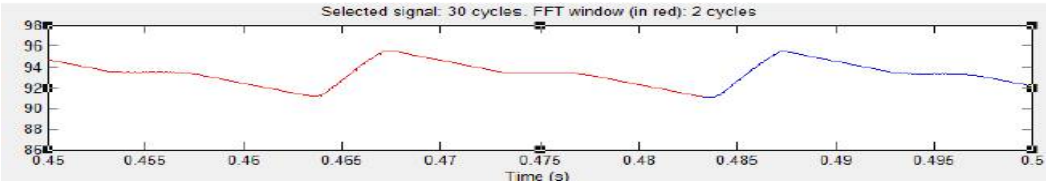

Figure 10. V.of Neutral Leg Single Phase Rectifier

With R_+ only Load

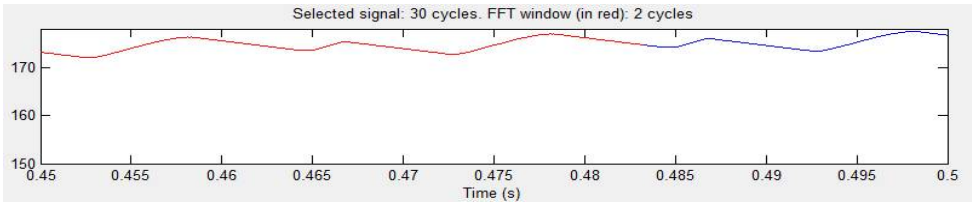

Figure 11. Voltage across R - Load for R_+ only Load

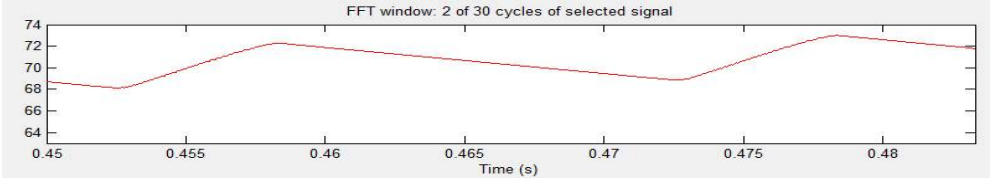

Figure 12. Voltage across R_+ Load for R_+ only

Neutral Leg Single Phase Rectifier with InputFilter

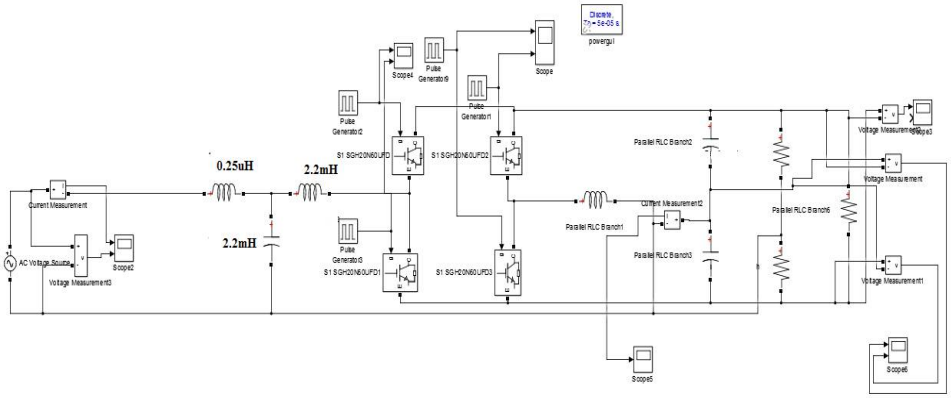

Figure 13. Simulink Model of Neutral Leg Single Phase Half Bridge Rectifier with Input

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Filter

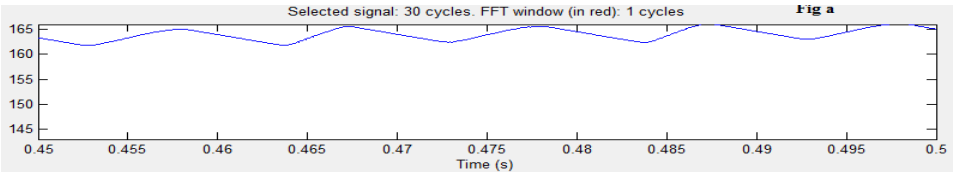

Figure 14. V_{DC} of Neutral Leg Single Phase Half Bridge Rectifier with Input Filter

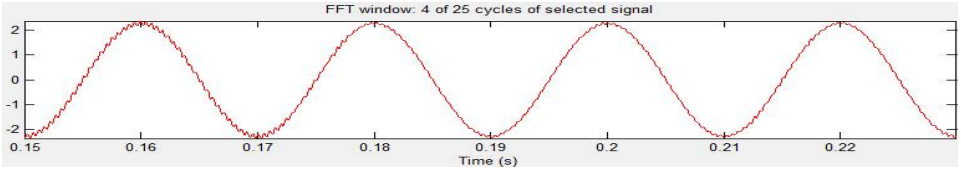

Figure 15. Input Current

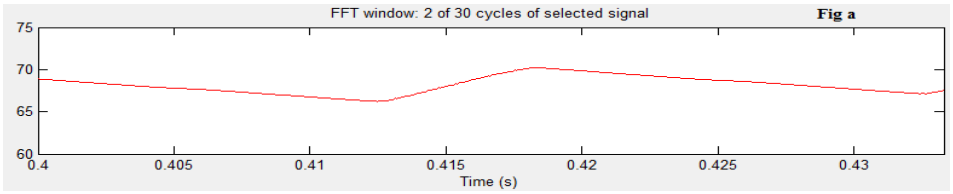

Figure 16. V_{+} of Neutral Leg Single Phase Half Bridge Rectifier with Input Filter

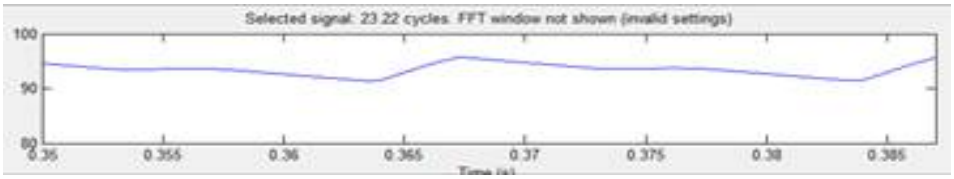

Figure 17. V_{-} of Neutral Leg Single Phase Half Bridge Rectifier with Input Filter

The Input current is observed to be sinusoidal by connecting a Filter in the input side of the neutral leg rectifier.The voltage across the R load is observed varying 165V and 162V and the voltageripple is observed as 3V. The voltage across the R+ is observedvarying 67V and 70V and the voltage across the R-is observed varying 93V and 96V.

COMPARATIVE STUDY

Table 2Voltage Ripples of Different Systems

SYSTEM	V_{DC}	V_{+}	V_{-}
Conventional System	5V	6V	5V
Neutral System	4V	4V	4V
Neutral system with filter	3V	3V	2.8V

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The voltage ripples in conventional Single Phase System is greater and the voltagesare dependent to each other. By introducing a Neutral leg to Conventional single phaseRectifier, makes the voltages independent and the voltage ripples are reduced.

V. CONCLUSIONS

The voltage ripples in conventional Single Phase System is greater and the voltagesare dependent to each other.By introducing a Neutral leg to Conventional single phaseRectifier, makes the voltages independent and the voltage ripples are reduced.NeutralLeg Single Phase Rectifier consists of a rectification leg and a neutral leg.The output voltage ripples can be reduced because the fundamental current component that originally flows through the split capacitors can be diverted and flows through the neutral leg. On the other hand, the two voltage outputs are independent with each other and are robust against with system parameters.The Neutral Leg Single PhaseSystem with input filter further reduces the voltage ripples,makes the input current sinusoidal and voltage ripples are reduced as compared to other two systems.

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